

MEMORANDUM FOR: Clifton S. Middleton  
Project Director, Survey Section B

FROM: Charles W. Challstrom  
Director, National Geodetic Survey

SUBJECT: INSTRUCTIONS: PENNSYLVANIA FBN, 2000  
(GPS-1463)  
Task Numbers: 8K6D2000 (FBN)  
8K6D4000 (CORS FBN/CBN TIE)

GENERAL:

The National Geodetic Survey (NGS), in accordance with the NGS Strategic Plan, is engaging in a campaign of observing stations of the Federal Base Network (FBN) to complete the ellipsoidal and orthometric height components of the FBN. This survey will observe the 18 FBN stations in Pennsylvania.

Four FBNs have been found unsuitable for GPS occupation and are being replaced by other stations. They are as follows: OAKLEY is replaced by F 279 (PID LY1654), BEARTOWN 2 is replaced by 40N I (PID AA9276), CONCORD RESET RM 4 is replaced by ROSTPORT (PID KX2372), and KIM RESET is replaced by CASTPORT (PID MB3011).

Also, five stations have been included to serve as bench mark ties only. They are as follows: A 404 (PID MA1737), K 358 PADH (PID KW2440), OYES (PID KW1255), R 408 (PID MA1807), and T 404 (PID KX1902).

In addition, at each of two Continuously Operating Reference Station (CORS) sites, a pair of CORS reference marks is to be tied to both the local FBN/CBN and the CORS antenna. The two CORS are Penn State and Wilkes Barre. Details for each are given under SPECIFICATIONS.

Also, stations M 365 (PID KW2677), GOSPEL HILL RM 2 (PID KX0065), and T 1 RDGRR RESET 1953 (PID KV2203) have been added to the project in order to check ellipsoid heights versus leveling. The stations are to be observed to FBN specifications.

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Lastly, a station at each of two tide sites is also included in the project and is to be surveyed to FBN specifications. The two tide sites are Philadelphia and Erie.

A full-wavelength, dual-frequency Global Positioning System (GPS) receiver is needed to act as Central Temporary CORS (CTCORS) throughout the project. The receiver shall be deployed at relatively secure stations within the vicinity of the ongoing observing sessions. The receiver shall continuously collect data at a 30-second epoch collection interval for a minimum of 72 hours and for as long as observations are ongoing in the vicinity of the CTCORS.

A total of approximately 103 Cooperative Base Network (CBN) stations may be co-observed by up to 17 different organizations. The coordinator is Mr. Brad Foltz, Pennsylvania Department of Transportation. The project will be performed under the technical management of NGS.

#### PURPOSE:

In order to meet America's accelerating positioning and navigation needs, the existing coordinate reference system must be continually enhanced to provide the accessibility and high accuracy required for use with GPS. The digital revolution in mapping, charting, and surveying requires a National Spatial Reference System (NSRS) consisting of, among other components, a network of monumented points having four-dimensional positions. The FBN fulfills the requirements for this component. NGS is charged with the Federal responsibility for establishment, observation, monitoring, and maintenance of the FBN. The FBN provides the critical network foundation for an accurate, consistent, reliable NSRS.

The NSRS, in turn, provides the common geographic framework for America's spatial data infrastructure. As such, the NSRS serves as the basis for mapping, charting, navigation, boundary determination, property delineation, infrastructure development, resource evaluation surveys, and scientific applications, including crustal motion monitoring, modeling of flooding, storm surge, pollution trajectories, and agricultural runoff. A modernized, accurate, consistent, reliable NSRS is of enormous benefit to state, county, tribal, local, and Federal authorities, as well as to the private sector.

The reference marks established at each of the two CORS sites will provide a very accurate tie to the antenna as an aid to reposition the antenna should that become necessary. The FBN/CBN tie to the reference marks will also provide site station coordinates relative to the local FBN/CBN, thus reducing the potential for relative error between the reference marks and the local network. It will also provide a check on the FBN/CBN, relative to the CORS coordinates.

#### SPECIFICATIONS:

Project requirements for the FBN observations are to ensure 2-centimeter local accuracy in the horizontal component, as well as 2-centimeter local accuracy for the ellipsoid heights.

Data from the CORS in the region are to be used in the processing. There are nine NGS CORS in the area to be selected from. Three are in Pennsylvania; two are in New York; and one each is in Delaware, Maryland, New Jersey, and Michigan.

The three NGS CORS in Pennsylvania are Pittsburgh (PIT1), Penn State (PSU1), and Wilkes Barre (WIL1). The two CORS in New York are Syracuse (SYCN) and Youngstown (YOU1). The CORS in Delaware is Reedy Point (RED1). The CORS in Maryland is Gaithersburg (GAIT). The CORS in New Jersey is New Jersey IT (NJIT). The CORS in Michigan is Detroit (DET1). Positions and data for the NGS CORS are available from the NGS web site.

General specifications for the project are as follows. At each FBN site, three sessions of 5 1/2 hours duration for each session shall be observed. The observing scheme shall be arranged so that for each station, the start time of one of the observing sessions shall be at least 4 hours different from the other two. The observing scheme shall be arranged to ensure that adjacent FBN stations are directly connected in at least one observing session, and at least half of all base lines are repeated.

Specific to the two CORS sites is that for the two reference marks at each site, two sessions of 2 hours each shall be observed. In order to provide a check, the equipment shall be broken down and reset with a minimum of 30 minutes between the two sessions. Since the CORS site is to be tied to the nearest FBN/CBN station, the FBN/CBN station must be occupied

simultaneously with the two reference marks. If the FBN/CBN tie station is part of the scheduled FBN or CBN to be occupied and is being occupied during a normal FBN/CBN session, occupy the station for the entire 5 1/2-hour session with no equipment breakdown. If the FBN/CBN station is not scheduled to be occupied as part of the project, do observe the two 2-hour sessions there and break down the equipment as described above.

Specifics for each of the CORS sites are as follows:

- (1) At the Penn State CORS, the reference marks are PSU1 A (No PID) and PSU1 B (no PID). The FBN/CBN tie station is MIFFPORT (PID KW3209), a scheduled FBN. The backup tie station is 0 0 (PID LZ2038), also a scheduled FBN.
- (2) At the Wilkes Barre CORS, the reference marks are WIL1 A (no PID) and WIL1 B (no PID). Since station OAKLEY is unsuitable for GPS occupation, the FBN/CBN tie station to use is BLOOMPORT (PID KW3200), a scheduled FBN. If BLOOMPORT is unusable, contact Doug Hendrickson, N/NGS21 (listed under LIAISON), for a backup station.

In general, station occupation and observing procedures must be carried out according to appropriate sections of the "NGS Operations Handbook" and the current applicable receiver field manuals. Data formats and digital file definitions are given in "Input Formats and Specifications of the National Geodetic Survey Data Base," Volume I. Horizontal Control Data, Federal Geodetic Control Subcommittee, September 1994, revised and reprinted November 1998. Success in meeting the accuracy standards will be based on repeatability of measurements and adjustment residuals.

General specifications for the project are given in "Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques," Version 5.0: dated May 11, 1988, reprinted with corrections August 1, 1989. Specific project criteria and deviations from the general specifications are given in the following sections.

Project Network - A list (Table 1) and sketch of stations involved in this project have been provided.

Data Acquisition - Data collection must be accomplished as specified in the appropriate dual-frequency receiver field manuals in the compressed mode at a 15-second epoch collection interval. The GPS receivers must be dual-frequency and full-wavelength. Track satellites down to a 10-degree elevation angle.

The satellite observing scenario has been provided in Table 2. Sessions will generally begin at two observing windows at least 4 hours apart - 1310 UTC and 1720 UTC. Vectors between the project stations shall be measured by single sessions consisting of continuously and simultaneously tracking for 5 1/2 hours.

Each FBN station must be occupied at least three times - twice at one observing window and once at the other. Each FBN station must be tied to two different bench marks. This bench mark tie requirement can be satisfied in one or two sessions. Adjacent FBN stations must be directly connected in at least one observing session, and at least one-half of all FBN base lines must be repeated. The CORS base lines will be repeated. CORS and CTCORS data will be used throughout the project.

For this project, each CBN station must also be occupied three times as described above. However, CBN stations can be tied to adjacent FBN stations (if the FBN station is closer than a CBN station), and a base line consisting of a CBN station and a FBN station can be used in the repeated-base line requirement mentioned above for the CBN portion of this project. The two bench mark tie requirement also applies to the CBN.

Record weather data just before, immediately after, and at the mid-point of each session. Meteorological data shall also be collected immediately after an obvious weather front passes during a session and immediately before it passes, if possible. Pressure and relative humidity measurements must be made near and at about the height of the GPS antenna phase center. Indicate in the log the location of the barometer and psychrometer.

Survey operations shall be conducted with due regard to the safety of personnel and equipment. Contact with the airport traffic control tower is mandatory during surveys at any controlled airports.

Vector Computations - Data management, quality review of collected data, and final vector processing for the FBN survey will be accomplished by the NGS project coordinator using PAGES. Vectors shall be computed in the International Earth Rotation Service Terrestrial Reference Frame (ITRF) system, using the most current epoch and precise IGS ephemerides. Use 30-second epoch intervals for data processing. Monument positions will be used for CORS when available, otherwise, antenna reference point (ARP) positions will be used. (Mr. Ajit Singh, N/NGS4, will be responsible for Pennsylvania.)

The data will be processed in 24-hour sessions (or slightly longer if the observation session crosses 0000 UTC) in order to utilize the 24-hour data sets collected at the CORS and CTCORS. The "fixed baseline" option in PAGES will be used to compute direct baselines between the CORS and CTCORS. The "fixed baseline" scheme will depend on the location and reliability of the CORS and CTCORS used in this project. Contact Ms. Juliana Blackwell, N/NGS41 (see LIAISON), for specific information relating to this project.

For stations where weather data are not available, or are suspect, predicted values computed based on the station's latitude, height above mean sea level, and time and day of year will be used. Use 15 degrees as the cutoff elevation angle in data processing. A cutoff angle of 10 degrees may be used when necessary to improve results.

The type of final solution, L1 versus ion-free, will depend on the length of the vectors. For vectors which are less than 10 km in length, the final reduction will consist of a L1 fixed solution. These vectors will be computed in a separate processing session from the longer vectors computed in an ion-free solution.

In general, vectors greater than 10 km in length are to be computed in an ion-free fixed, or partially-fixed, solution. In all cases, integer ambiguities will be fixed for each vector whenever possible.

For the two pairs of CORS reference marks, the CORS antenna at each site will be used as the reference station in the data processing.

The quality of collected data shall be determined from the plots generated from PAGES, by analysis of repeated vectors and/or comparison of station positions, and free adjustment residuals and/or loop misclosures. In addition, a constrained adjustment constraining all CORS will be performed.

The NGS project coordinator will perform all quality checks for conformance with NGS format standards such as executing software programs COMPGB, OBSCHK, and OBSDES. The final ITRF vectors will be assessed and transformed to the NAD 83 coordinate system using program ADJUST.

The data and results will be submitted to the Observation and Analysis Division. All B-files and G-files must be complete, including \*25\* and \*27\* records.

Station Descriptions - Station recovery notes must be submitted in computer-readable form using DDPROC software. Include the name, address, and, if public ownership, the telephone number of the responsible party. Do not include the telephone numbers of private property owners.

Special Requirements - Antenna set-up is critical to the success of this project. Fixed-height tripods are preferred for all receivers. The plumbing bubbles on the antenna pole of the fixed-height tripod must be shaded when plumbing is performed. They must be shaded for 3 minutes before checking and/or re-plumbing. Also, the perpendicularity of the poles must be checked at the beginning of the project and any other time there is suspicion of a problem.

When a fixed-height tripod is not used, the height of the antenna must be carefully measured to prevent station set-up blunders from occurring. Tribrachs used for these set-ups must be checked and adjusted when necessary. Totally independent measurements of the antenna height above the mark in both metric and English units must be made before and after each session. Someone other than the observer must check the measurement computations by carefully comparing measurements and then entering his/her initials on the log.

Some GPS antennas have detachable ground planes and radomes. In order to help identify what exactly was used at a particular site, it would be useful to have a snapshot of the setup. All co-observers should take a photograph of the setup, if possible, with a close-up of the antenna as viewed from the side.

In addition, a rubbing of the stamping of the mark must be made at each visit to a station. If it is impossible to make a rubbing of the mark, a plan sketch of the mark must be substituted, accurately recording all markings.

Also, for each station visited, a visibility obstruction diagram must be prepared and the TO-REACH description carefully checked for errors or omissions.

Lastly, the following must be recorded at each occupation of a station:

- (1) receiver manufacturer,
- (2) antenna manufacturer,
- (3) receiver model number (part number),
- (4) antenna model number (part number),
- (5) the complete serial number of the receiver, and
- (6) the complete serial number of the antenna.

Success of this project requires that the highest quality GPS data be collected. Therefore, during each station occupation, the operators shall carefully monitor the operation of the receivers. Any irregularities in the data due to equipment malfunction, DOD adjustment of the satellite orbit, obstructions, etc., must be reported to the Field Operations Branch, N/NGS41, as soon as possible and noted on the observing log. If the quality of observations for an observing session is questionable, notify the Field Operations Branch immediately.

The survey team shall not depart the project area until they have quality reviewed all data, advised N/NGS21, and notified N/NGS41.

#### GPS DATA:

Visibility tables and plots of the present satellite constellation for April 10, 2000, have been reviewed and two observing windows selected. For operational use, current data



must be generated with Trimble mission planning software or from program SATMAP.

Project report and data listed in Annex L of "Input Formats and Specifications of the NGS Data Base" and in the attached addendum for the adjustment portion must be transmitted. Any data considered suspect as to quality in achieving accuracy standards should be sent via FedEx immediately for office review. Backup of transmitted data must be held until notified by the Field Operations Branch, N/NGS41.

The data set collected during the project shall be named "paro040d.752". All records in connection with this project shall be titled "PENNSYLVANIA FBN, 2000". The project number (accession number) is GPS-1463.

LIAISON:

Liaison must be maintained with designated offices at the National Geodetic Survey headquarters located at:

1315 East-West Highway  
Silver Spring, Maryland 20910-3282

Questions and problems concerning survey field operations should be directed to:

William T. McLemore, Jr.  
Chief, Field Operations Branch  
Observation and Analysis Division  
N/NGS41, SSMC III, Station 8564  
Telephone: 301-713-3215, ext. 117  
Fax: 301-713-4327  
e-Mail: [mclemore@ngs.noaa.gov](mailto:mclemore@ngs.noaa.gov)

Questions and problems concerning adjustment processing should be directed to:

Maralyn L. Vorhauer  
Observation and Analysis Division  
N/NGS4, SSMC III, Station 8562  
Telephone: 301-713-3176, ext. 104  
Fax: 301-713-4327  
e-Mail: [maralyn@ngs.noaa.gov](mailto:maralyn@ngs.noaa.gov)

Questions and problems concerning vector processing should be directed to:

Juliana Blackwell  
Field Operations Branch  
Observation and Analysis Division  
N/NGS41, SSMC III, Station 8458  
Telephone: 301-713-3215, ext. 108  
Fax: 301-713-4327  
e-Mail: Juliana.Blackwell@noaa.gov

Questions and problems concerning using CORS data in processing should be directed to:

Neil Weston  
Geosciences Research Division  
N/NGS6, SSMC III, Station 9830  
Telephone: 301-713-2847, ext. 202  
Fax: 301-713-4475  
e-Mail: nweston@ngs.noaa.gov

Questions and problems which could affect the technical adequacy of the project should be directed to:

Stephen J. Frakes (Douglas R. Hendrickson)  
Chief, Project Development Branch  
Spatial Reference System Division  
N/NGS21, SSMC III, Station 8853  
Telephone: 301-713-3194, ext. 111 (ext. 127)  
Fax: 301-713-4316  
e-Mail: steve@ngs.noaa.gov (dough@ngs.noaa.gov)

The NGS project coordinator is:

Ajit Singh  
Observation and Analysis Division  
N/NGS4, SSMC III, Station 8517  
Telephone: 301-713-3182, ext. 109  
Fax: 301-713-4327  
e-Mail: singh@ngs.noaa.gov

For tide site information, contact:

Bruce Servary  
Center for Operational Oceanographic  
Products and Services  
Requirements and Development Division  
N/OPS1, SSMC IV, Station 6425  
1305 East-West Highway  
Silver Spring, Maryland 20910  
Telephone: 301-713-2897, ext. 183  
e-Mail: Bruce.Servary@noaa.gov

The contacts for the CORS (allow 3 or 4 days notice) are:

for Penn State:

Greg Shufran, P.L.S.  
Civil and Environmental Engineering  
The Pennsylvania State University  
206J Sackett Building  
University Park, PA 16802-1408  
Telephone: 814-863-2935  
Fax: 814-863-7304  
e-Mail: gshufran@engr.psu.edu

for Wilkes Barre:

Dr. Charles D. Ghilani or Wesley Parks  
Pennsylvania State University/Wilkes-Barre Campus  
P.O. Box PSU  
Lehman, PA 18627-0217  
Telephone: 570-675-9127  
e-Mail: cdg3@psu.edu

The coordinator for the CBN is:

Mr. Brad Foltz  
Pennsylvania Department of Transportation  
Building 28  
Harrisburg International Airport  
Middletown, PA 17057  
Telephone: 717-783-1519, ext. 3002  
Fax: 717-948-3826  
e-Mail: lbfoltz@aol.com

Other CBN contacts are:

Mr. Richard McDonald  
Michael Baker, Inc.  
4301 Dutch Ridge Road  
Beaver, PA 15009-0280  
Telephone: 724-495-7711  
Fax: 724-495-4266  
e-Mail: rmcdonald@mbakercorp.com

Mr. Larry Straight  
ADR  
280 Kappa Drive  
Pittsburgh, PA 15238  
Telephone: 412-967-9577  
Fax: 412-967-9564

Mr. Eric Jespersen  
Rettew Associates, Inc.  
3020 Columbia Avenue  
Lancaster, PA 17603  
Telephone: 717-394-3721  
Fax: 717-394-1063

Mr. John Neidich  
Pennsylvania Department of Transportation  
District 1  
255 Elm Street  
Oil City, PA 16301  
Telephone: 814-437-7108  
Fax: 814-678-7030  
e-mail: plumbbob@csonline.net

Mr. D. Paul Boord  
Pennsylvania Department of Transportation  
District 12  
825 North Gallatine Avenue  
Uniontown, PA 15401  
Telephone: 724-439-7338  
Fax: 724-439-7381  
e-Mail: bh100@lcsys.net

Mr. Barry Williams  
Pennsylvania Department of Transportation  
District 2  
1924 Daisy Street  
Clearfield, PA 16830  
Telephone: 814-765-0484  
Fax: 814-765-0424

Mr. Michael Maneval  
Pennsylvania Department of Transportation  
District 3  
715 Jordan Avenue  
Montoursville, PA 17754  
Telephone: 570-368-4252  
Fax: 570-368-4321  
e-Mail: mtmpls@epix.net

Mr. Kenneth Quigley  
Pennsylvania Department of Transportation  
District 8  
2140 Herr Street  
Harrisburg, PA 17103-1699  
Telephone: 717-787-6104  
Fax: 717-787-6662

Mr. Dale Haynes  
Pennsylvania Department of Transportation  
District 9  
1620 N. Juniata Street  
Hollidaysburg, PA 16648  
Telephone: 814-696-7212  
Fax: 814-696-7103  
e-Mail: dalesurvey@hotmail.com

Mr. Anthony Dubyk  
Pennsylvania Department of Transportation  
District 6  
7000 Geerdes Boulevard  
King of Prussia, PA 19087  
Telephone: 610-205-6548  
Fax: 610-694-6668  
e-Mail: anthonydubyk@juno.com

Mr. Phillip Navitsky  
Pennsylvania Department of Transportation  
District 5  
1713 Leigh Street  
Allentown, PA 18103  
Telephone: 610-798-4222  
Fax: 610-798-4116  
e-Mail: pnpls@hotmail.com

Mr. Chet Lukasiewicz  
Pennsylvania Department of Transportation  
District 4  
Keystone Industrial Park  
O'Neill Highway  
Dunmore, PA 18512  
Telephone: 570-963-4003  
Fax: 570-963-4014  
e-Mail: calpls00@hotmail.com

Mr. Thad Mikolajczyk  
Pennsylvania Department of Transportation  
District 10  
Route 286 South  
Indiana, PA 15701  
Telephone: 724-357-2474  
Fax: 724-357-2872

Mr. William Somplatsky  
Pennsylvania Department of Transportation  
District 11  
45 Thoms Run Road  
Bridgeville, PA 15017  
Telephone: 412-429-4916  
Fax: 412-429-5069  
e-Mail: efentzell@hotmail.com

Mr. Tom Farcht  
Pennsylvania Turnpike Commission  
176 Kost Road  
Carlisle Pike, PA 17013  
Telephone: 717-939-9551  
Fax: 717-986-8706

A possible CBN participant who will assist if needed is:

Mr. Eric Orndorff  
Herbert, Rowland & Grubic  
1846 Charter Lane  
Lancaster, PA 17601  
Telephone: 717-291-1783  
e-Mail: eorndorff@hrg-inc.com

Names and telephone numbers of local contacts are given in the station description material.

ADDRESS:

Keep N/NGS41 informed of the party's post office, physical address, and telephone number at all times.

PUBLICITY:

See "NGS Operations Handbook," Section 1.4.1.

EXPENSES:

FBN expenses for this project will be charged to task number 8K6D2000. Expenses for the CORS FBN/CBN tie will be charged to task number 8K6D4000.

TRAVEL:

Travel and per diem are authorized in accordance with Federal Travel Regulations, Part 301-11, Per Diem Allowances. Current per diem rates were effective January 1, 2000.

ACKNOWLEDGMENT:

Please acknowledge receipt of these instructions in your Monthly Report.

cc: N/NGS - D. Zilkoski\*  
 N/NGS - S. Misenheimer\*  
 N/NGS1 - G. Mitchell  
 N/NGS11 - S. Cofer  
 N/NGS21 - S. Frakes  
 N/NGS21 - R. Anderson  
 N/NGS21 - D. Hendrickson\*  
 N/NGS22 - T. Soler  
 N/NGS3 - E. Allen  
 N/NGS4 - E. Wade  
 N/NGS4 - M. Vorhauer  
 N/NGS4 - D. Hoar  
 N/NGS4 - A. Singh  
 N/NGS41 - W. McLemore  
 N/NGS41 - J. Blackwell  
 N/NGS5 - R. Snay  
 N/NGS6 - N. Weston  
 N/OPS1 - B. Servary  
 FGCS Members\*  
 Brad Foltz, Pennsylvania Department of Transportation  
 Richard McDonald, Michael Baker, Inc.  
 Larry Straight, ADR  
 Eric Jespersen, Rettew Associates, Inc.  
 John Neidich, Pennsylvania Department of Transportation  
 D. Paul Boord, Pennsylvania Department of Transportation  
 Barry Williams, Pennsylvania Department of Transportation  
 Michael Maneval, Pennsylvania Department of  
 Transportation  
 Kenneth Quigley, Pennsylvania Department of  
 Transportation  
 Dale Haynes, Pennsylvania Department of Transportation  
 Anthony Dubyk, Pennsylvania Department of Transportation  
 Phillip Navitsky, Pennsylvania Department of  
 Transportation  
 Chet Lukasiewicz, Pennsylvania Department of  
 Transportation  
 Thad Mikolajczyk, Pennsylvania Department of  
 Transportation  
 William Somplatsky, Pennsylvania Department of  
 Transportation  
 Tom Farcht, Pennsylvania Turnpike Commission  
 Greg Shufman, Pennsylvania State University  
 Charles Ghilani, Pennsylvania State University  
 Bob Garlitz, Pennsylvania NSPS Governor  
 Chuck Harpster, Pennsylvania Department of Transportation  
 Ed Northrop, PSLHS HARN Committee



Eric Orndorff, Herbert, Rowland & Grubic  
Wesley Parks, Pennsylvania State University

\* first page only

**DATA TO BE SENT TO HEADQUARTERS RELATING TO  
THE ADJUSTMENT PORTION OF  
FBN/CBN PROJECTS**

Free adjustment in NAD 83 (UNIX run).

Plots of the free adjustment created by running "plotres\_prompt.bsh" on a UNIX server. Plots require a printer that supports postscript. The output file (long.out) contains a list of residuals which may be sorted using the following commands:

```
vi long.out
:1,$ !sort +0.47 (sorts horizontal residuals)
:1,$ !sort +0.71 (sorts vertical residuals)
```

(OPTIONAL) Constrained horizontal adjustment holding NGS CORS positions and ellipsoid heights.

Final combined Blue Book file (ASCII required) with \*86\* records (GEOID99).

Final description file (ASCII required.)

Final G-file (ASCII required.)

OBSCHK output.\*

CHKDDESC output.\*

OBSDES output.\*

\*Any errors or warning messages must be explained.